Network Modeling and Simulations for Internet Services

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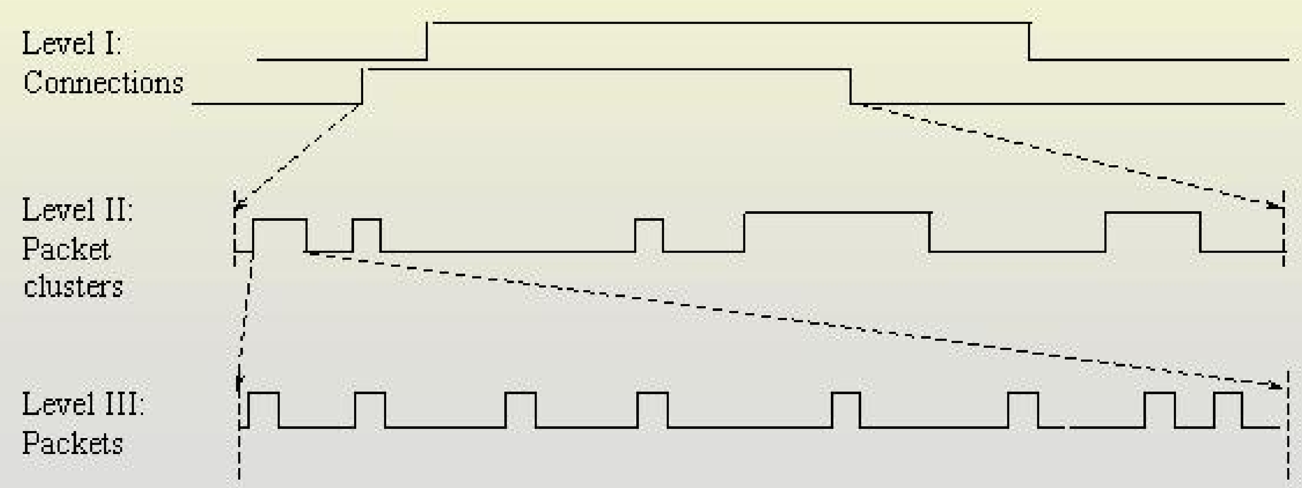
Objectives

- **Design of a structural Internet traffic model**
  - It involves practical network and protocol parameters, and can inherently show multi-scaling behavior.
- **Physical interpretation of multi-scaling traffic**
  - Establishing relations between network/protocol parameters and multi-scaling behaviors.
- **Performance modeling of multi-scaling traffic**
  - Understanding how multi-scaling characters affect network performance.
- **Traffic management for future Internet**
  - Deciding how to control the multi-scaling traffic and improve quality of services by managing network/protocol parameters.

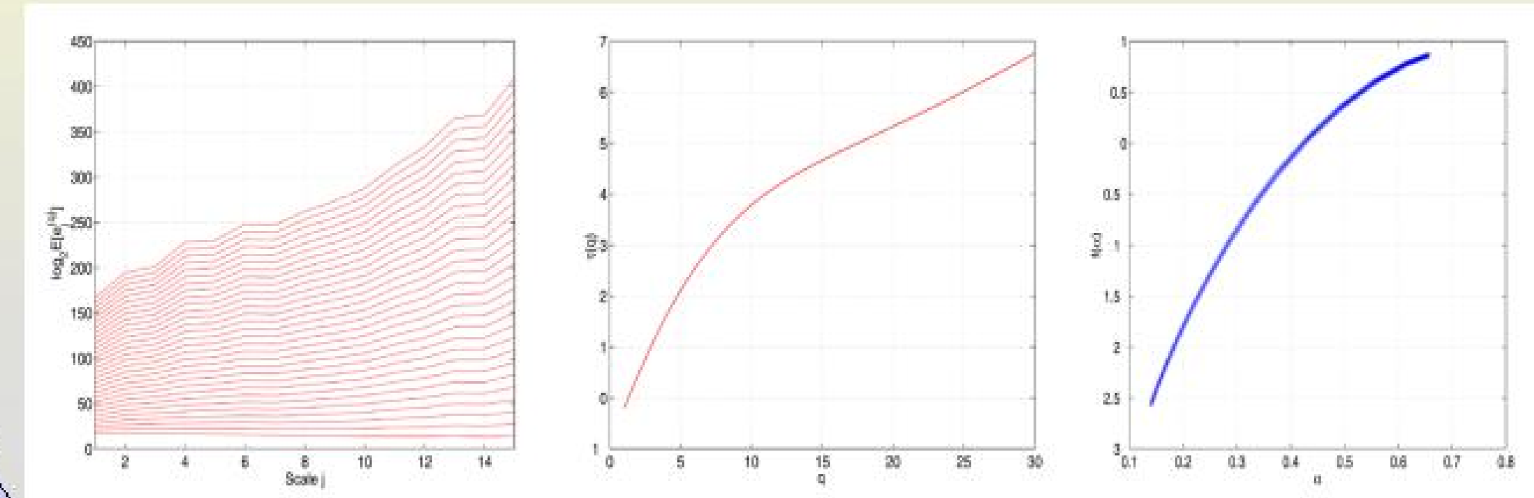
Hierarchical On-Off (HOO) Model

- Structurally imitating TCP traffic in multiple resolutions.
- Involving parameters from connection level to packet level
- Explicitly modeling protocol effect of TCP
- Level I is a $G/G/\infty$ or $M/G/\infty$ process
- Exhibiting long-range dependent and multifractal behaviors



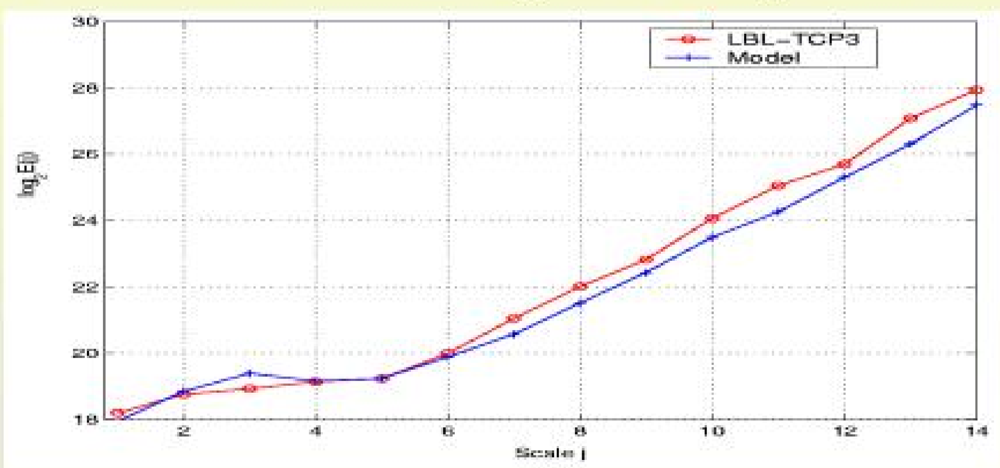
Multifractality of HOO Model

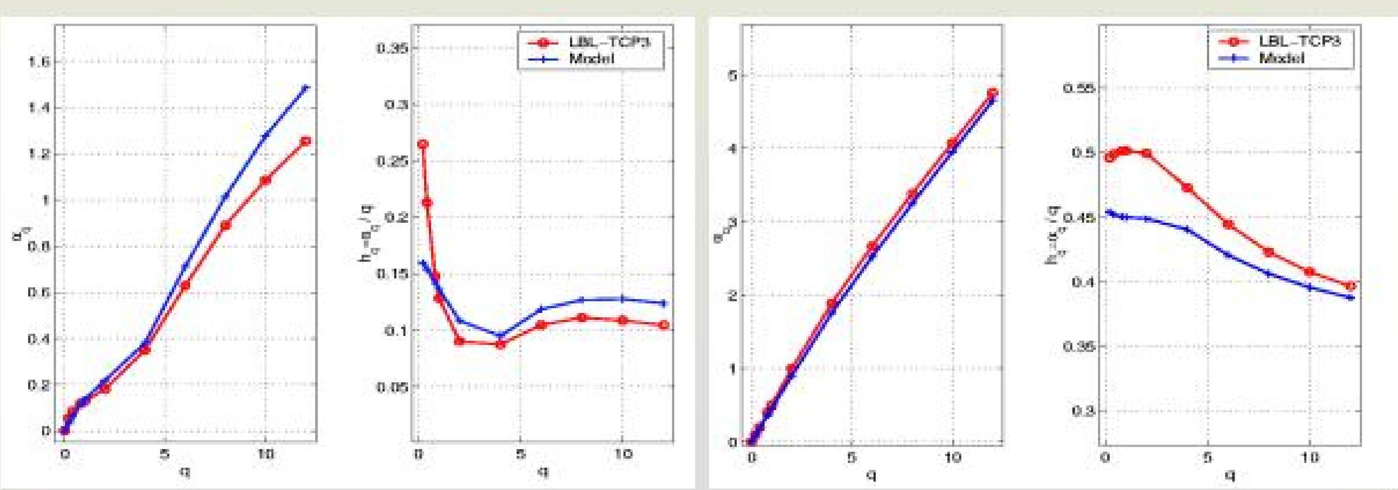
- Left: wavelet partition function. It shows different orders of moments have non-uniform scaling parameters.
- Middle: structure function. The concaveness of it indicates the multi-scaling property.
- Right: multifractal spectrum. It displays the rich scaling structure.



Matching Real Traffic

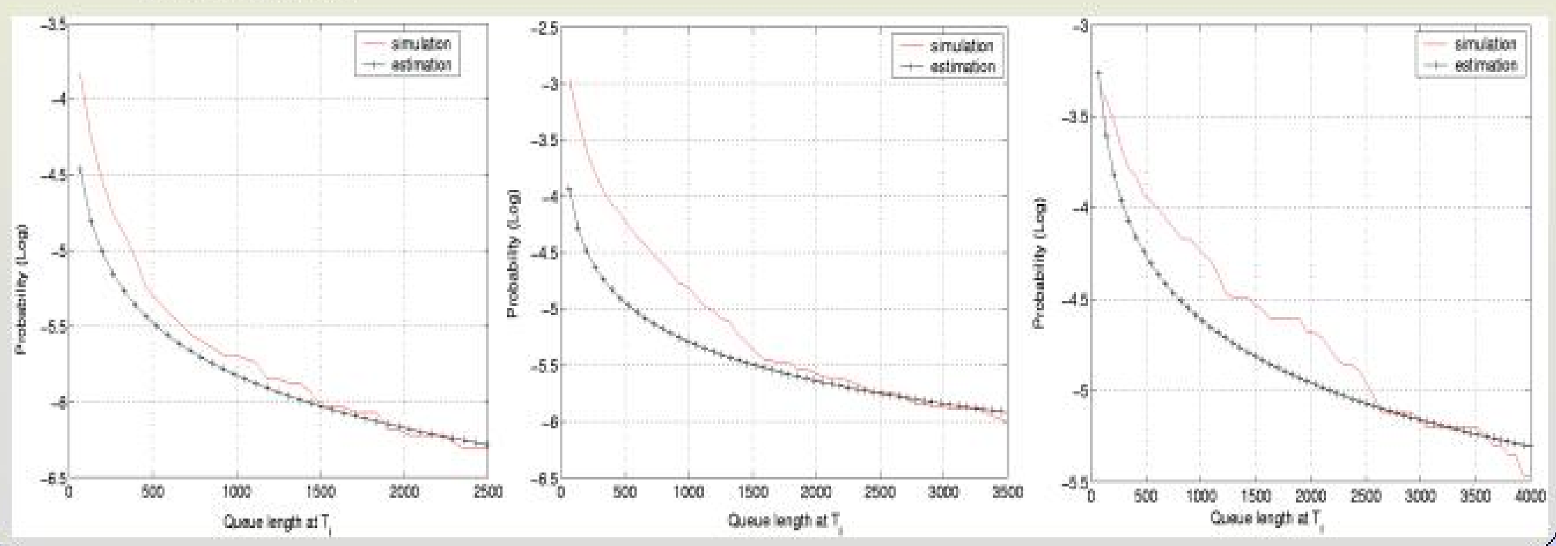
- LBL-TCP3 is a trace of one hour of TCP traffic from LBL
- Top: matching of 2nd-order scaling structure
- Bottom: matching of scaling structures in many diff. orders.
  Left: for small time scales; Right: for large time scales





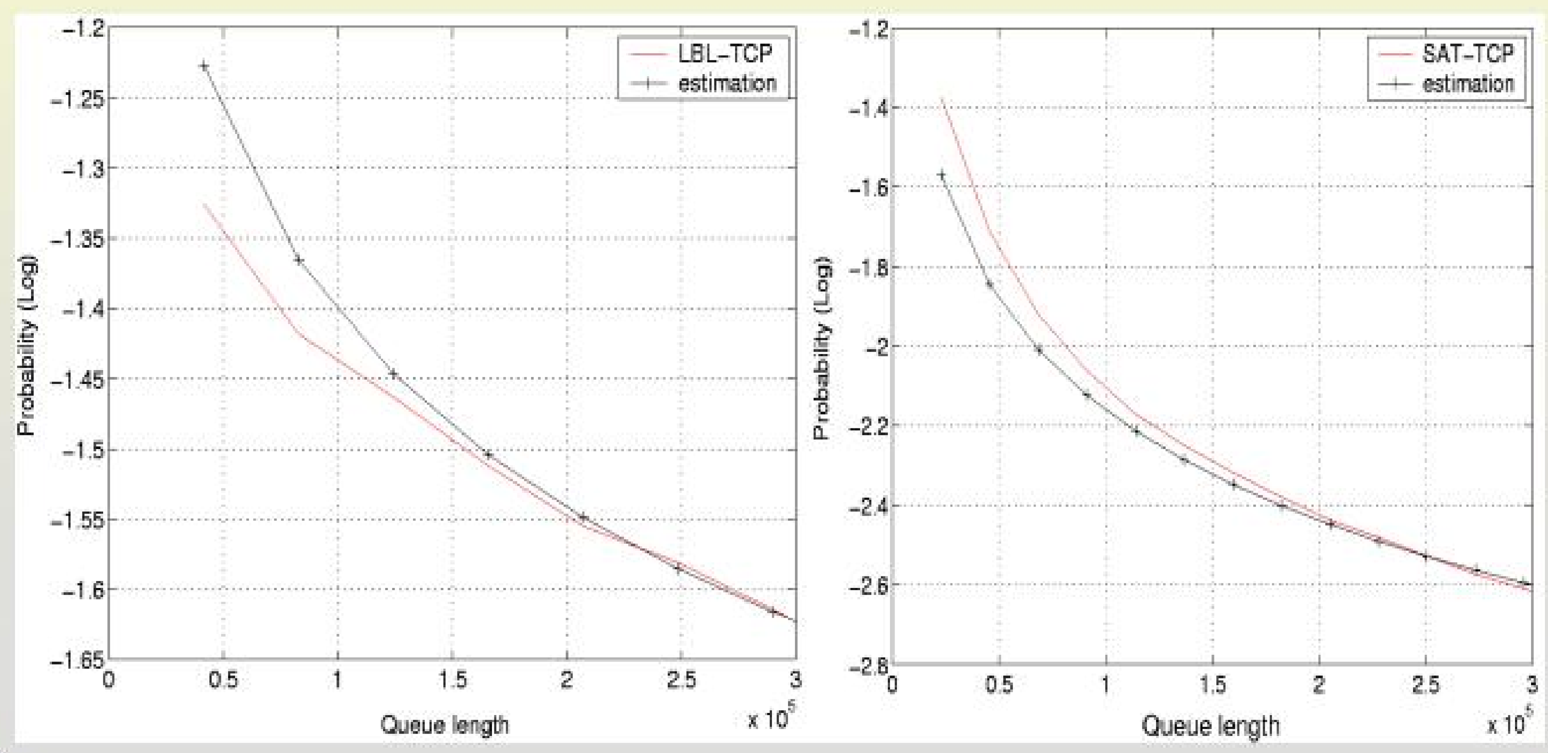
Predicting Queueing Performance (I)

- Queueing analysis of the HOO model:
  $$\text{Prob}[Q>x] \sim \beta x^{\alpha-1},$$
  where β is a coefficient related with 1st-order statistics of the traffic, and α is the index of the tail of the connection length.
- Queueing performance can be predicted with a simple statistical inference method based on the queueing analysis.
- Simulations
  From left to right are comparisons of simulated queue tails with prediction results in different traffic loads: 20%, 30%, and 80%.



Predicting Queueing Performance (II)

- Predicting queue tails for real traffic traces.
  The left is for trace LBL-TCP, which has an average rate of 282.12Kbps. The right is for trace SAT-TCP, a TCP trace from NASA. It has an average rate of 4.39Mbps. Their traffic loads are 56.42% and 68.59%, respectively.



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